CANADA

National Energy Board

Reasons for Decision

Interhome Energy Inc.

which carries on its pipeline operations as "Interprovincial Pipe Line Company, a division of Interhome Energy Inc."

OHW-1-89

September 1990

National Energy Board

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which carries on its pipeline operations as "Interprovincial Pipe Line Company, a division of Interhome Energy Inc."

Review of Recommendation 5.9: Integrity of Existing Pipelines, of the National Energy Board Report MH-2-85 dated June 1986.

IN THE MATTER OF

An Accident on 19 February 1985 Near Camrose, Alberta, on the Pipeline System of the Interprovincial Pipe Line Company Limited

OHW-1-89

September 1990

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Recital and Submittors

IN THE MATTER OF the *National Energy Board Act* ("the Act") and the regulations made thereunder; and

IN THE MATTER OF the National Energy Board Report MH-2-85 dated June 1986 regarding an accident near Camrose, Alberta on 19 February 1985, on the pipeline system of Interprovincial Pipe Line Company Limited (now Interhome Energy Inc. carrying on its pipeline activities as "Interprovincial Pipe Line Company, a division of Interhome Energy Inc."); and

IN THE MATTER OF a review held by the Nationa Energy Board pursuant to subsection 21(1) of the Act under Directions on Procedure OHW-1-89, filed with the Board under File No. 1764-J1-2.

EXAMINED by means of written submissions.

B E F O R E:

D.B. Smith	Presiding Member
R. Priddle	Member
R.B. Horner, Q.C.	Member

SUBMITTORS:

Amoco Canada Petroleum Company Ltd. on behalf of Amoco Canada Resources Ltd. (formerly Dome Petroleum Limited)

Canadian Petroleum Association

Canadian Pipeline Industry Committee

Esso Resources Canada Limited

Interhome Energy Inc. (formerly Interprovincial Pipe Line Company Limited)

Montreal Pipe Line Limited

Murphy Oil Company Ltd.

Petroleum Transmission Company

Trans Mountain Pipe Line Company Ltd.

Trans-Northern Pipelines Inc.

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Abbreviations

Act	*National Energy Board Act*
Amoco	Amoco Canada Resources Ltd. (formerly Dome Petroleum Limited)
Board	National Energy Board
CE	carbon equivalent
the Committee	Canadian Pipeline Industry Committee
CPA	Canadian Petroleum Association
ECA	engineering critical assessment
Esso	Esso Resources Canada Limited
HVP	high vapour pressure
IPL	Interhome Energy Inc. (formerly Interprovincial Pipe Line Company Limited)
km	kilometre(s)
LVP	low vapour pressure
m	metre(s)
mm	millimetre(s)
MPL	Montreal Pipe Line Limited
Murphy	Murphy Oil Company Ltd.
NDT	nondestructive testing
PTC	Petroleum Transmission Company
TMPL	Trans Mountain Pipe Line Company Ltd.
TNPL	Trans-Northern Pipelines Inc.

Overview

(Note: This overview is provided solely for the convenience of the reader and does not constitute part of this Decision or the Reasons, for which the readers are referred to the detailed text, figure and tables.)

Pursuant to an application, dated 6 October 1986, by Interhome Energy Inc. ("IPL") the National Energy Board ("the Board") conducted a review of Recommendation 5.9, contained in its report MH-2-85, in the matter of an accident on 19 February 1985 near Camrose, Alberta, on the pipeline system of IPL. This recommendation addressed the integrity of welds made to liquid-filled pipe already existing on pipelines under the Board's jurisdiction. The review process was conducted in two phases: first, the parties operating such pipelines were given time to sample the welds on their respective pipelines to obtain further evidence; and, second, the review itself was carried out. Each party that submitted sampling results also provided its comments on their significance, along with proposals for further measures where it had judged such measures to be necessary.

As a result of the review, the Board has decided to rescind Recommendation 5.9 and to substitute therefor new requirements applicable, as a minimum standard, to all pipeline companies under the Board's jurisdiction. The scope of these requirements extends to welds performed before 23 July 1986 to liquid-filled pipe, except branch connection welds located under reinforcing fittings. The Board has also decided on the acceptability of the company-specific submissions it received.

Under the new requirements, the need for integrity programs in respect of full encirclement fillet welds is based on the actual condition of a pipeline as determined through representative sampling, and not on estimation of susceptibility to cracking by analysis. Companies that have welds within the scope of this decision and that have not yet conducted satisfactory sampling are now required to do so. The objective of the sampling is to determine whether a pipeline system or portion thereof is affected by recurrent full encirclement fillet weld root or toe cracking. With the exception of Zone 2 areas of high vapour pressure ("HVP") pipelines, integrity programs must consist of nondestructive testing and, where required, remedial action in accordance with the Board's decision on Recommendation 5.11. In Zone 2 areas of HVP pipelines, integrity programs, where required, must consist of fillet weld removal by cut out or containment by sleeve-on-sleeve assemblies.

Under the new requirements, buried branch connection welds within the scope of this decision must be nondestructively tested and repaired, if necessary, when they are uncovered for any reason. In addition, all above-ground branch connection welds within the scope of this decision must be inspected and repairs carried out, if required, as soon as is practicable. The new requirements are detailed in Chapter 10 Section 10.1, and are presented schematically in Appendix I.

Chapter 1

Introduction

1.1 Background

On 19 February 1985, approximately 27 km north-east of Camrose, Alberta, a line break occurred on the 508 mm diameter pipeline of Interhome Energy Inc. ("IPL")[1] designated as Line 1. The line break allowed natural gas liquids to escape to the atmosphere and to form a vapour cloud. Some nine hours after the line break, the escaping natural gas liquids accidentally ignited. The ensuing fire engulfed members of a pipeline maintenance crew which had responded to the line break, killing two persons and severely burning three others.

Pursuant to Order MH-2-85, the National Energy Board ("the Board") convened a public inquiry into the accident. Hearings were held in Edmonton from 26 to 30 March 1985 and from 22 to 24 October 1985. The Inquiry Panel's report was released on 23 July 1986.

The Inquiry Panel concluded that the line break occurred due to the sudden propagation of a crack in a fillet weld used to join a full encirclement sleeve to the carrier pipe. The fillet weld had been performed while the carrier pipe was liquid-filled. These circumstances resulted in rapid cooling of the weld and contributed to the formation of the crack. The Inquiry Panel made a series of twelve recommendations to the Board for measures intended to prevent similar accidents from recurring. On 1 August 1986, the Board adopted the Inquiry Panel's recommendations.

On 6 October 1986, IPL filed an application with the Board under section 17 (now section 21) of the *National Energy Board Act* ("the Act") for a review of Recommendation 5.9. This recommendation addressed the integrity of welds, made to liquid-filled pipe, already existing on pipelines under the Board's jurisdiction. In a decision dated 23 October 1986, the Board granted IPL's application for a review of the recommendation and granted a stay of implementation of the recommendation based on IPL's undertakings to take certain interim measures in respect of its Line 1. Those measures involved removing sleeves from Zone 2 locations and from Zone 1 locations[2] where clusters of sleeves existed. Although the Board initially indicated a preference for conducting the review by way of a public hearing, it decided to seek the views of interested parties regarding the review process.

As a result of the comments received, the Board decided on 22 December 1986 to begin the review of Recommendation 5.9 with a technical conference, reserving until its completion a decision as to whether to hold a public hearing. This conference, which was held in Calgary on 27 January 1987 between interested parties and senior Board staff, resulted in the creation of the Canadian Pipeline Industry Committee ("the Committee") which was formed to assist interested parties in drafting a consensus position for submission to the Board.

The Committee submitted its position paper on Recommendation 5.9 to the Board on 18 May 1988. It proposed that the review be carried out in two phases. During phase one, interested parties would have the opportunity to gather further evidence for the review. This evidence would be

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1. On 5 May 1988 Interprovincial Pipe Line Company Limited changed its name to Interhome Energy Inc. and began carrying on its pipeline operations as "Interprovincial Pipe Line Company, a division of Interhome Energy Inc."
2. Zone locations are defined in the Canadian Standards Association Standard CAN3-Z183-M86 to be as follows: A Zone 2 location is an area extending 200 m on either side of the centreline of any continuous 1 km length of an HVP pipeline that contains more than five dwelling units intended for human occupancy or a facility that contains 20 or more persons during normal use. Where a facility creates a Zone 2 locations, the Zone 2 location shall extend 200 m from that facility. A Zone 1 location is an area extending 200 m on either side of the centreline of any continuous 1 km length of an HVP pipeline that contains five or fewer dwelling units intended for human occupancy.

obtained by examining a proportion of each company's welds within the scope of the recommendation in accordance with a sampling plan submitted by the Committee. Subsequently, the review itself would take place as phase two. On 22 July 1988, the Board indicated its support for the two-phase approach and made comments on certain aspects of the Committee's sampling program. Prior to carrying out the sampling, each affected company was to submit its detailed inspection plans to the Board. The deadline for submission of the sampling results was set (after extension) as 31 December 1988 and the Board invited each company to provide comments on the significance of its inspection results.

On 1 June 1989, the Board issued Directions on Procedure OHW-1-89, as amended (Appendix II) respecting phase two. This phase, the review itself, was by means of written submissions, the final date for filings by interested parties being 3 November 1989.

In addition to the review of Recommendation 5.9 which was originally initiated by a formal request of IPL, it should be noted that on 31 March 1987, the Board decided to seek comments from interested parties on the eleven other recommendations contained in the MH-2-85 Inquiry Report. The Committee subsequently submitted position papers addressing each of these Recommendations. The Board's decisions were conveyed to the Committee Chairman on 22 January 1988 and 22 July 1988 in the form of letters, one covering each Recommendation.

1.2 The Recommendation Under Review

The following is the text of Recommendation 5.9 as it appears in the MH-2-85 Inquiry Report:

5.9 Integrity of Existing Pipelines

1. The Inquiry Panel recommends to the Board that all companies under the Board's jurisdiction, having performed any welding on liquid-filled pipe manufactured on or before 1970, be required by Board order to formulate a program and schedule for the removal of any such welds in Zone 1 and 2 locations on HVP pipelines and in locations which meet the requirements of Zone 2 on crude oil pipelines. The Inquiry Panel recommends that the Board require each company to seek and obtain Board approval for the program and schedule prior to its execution.

2. The Inquiry Panel recommends to the Board that all companies under the Board's jurisdiction, having performed any welds on liquid-filled pipe manufactured on or before 1970, in any location other than that specified in (1), be required by Board order to formulate a program and schedule for uncovering and nondestructively testing each such weld for cracking. The Inquiry Panel recommends that the Board require each company to seek and obtain Board approval for the program and schedule prior to execution. In lieu of nondestructive testing, a company may opt for removal of any welds performed on liquid-filled pipe manufactured on or before 1970.

3. The Inquiry Panel recommends to the Board that all companies under the Board's jurisdiction having performed welds on liquid-filled pipe manufactured after 1970, be required by Board order to uncover and nondestructively test a representative sampling of such welds for cracks. Companies would be required to report the results along with proposals for further action, if any, to the Board for approval.

4. For the purposes of the nondestructive testing in (2) and (3) above, the Inquiry Panel recommends to the Board that any weld flaw interpreted as a crack, regardless of dimensions, result in the rejection of the weld.

5. The Inquiry Panel recommends to the Board that any welds whose removal is required under (1) or (2) above, or which are rejected as a result of the nondestructive testing in (2) and (3), be removed by cutting out a cylindrical piece of pipe containing the defect and replacing it by butt welding in a section of pretested pipe that meets the design requirements. Companies should be required to take the necessary measures to perform such cut-outs without the application of new fillet welds to the pipeline.

1.3 The Review

Under phase one, five pipeline operators conducted sampling programs on their respective pipelines and submitted the results to the Board.

These operators were: Trans-Northern Pipelines Inc. ("TNPL"); Amoco Canada Resources Ltd. ("Amoco")[1] in respect of the Cochin Pipeline System, the Empress-Kerrobert Pipeline System, the Eastern Delivery System and the Sarnia Downstream System; Petroleum Transmission Company ("PTC"); Trans Mountain Pipe Line Company Ltd. ("TMPL"); and IPL. Each of these operators provided, along with the sampling results, its assessment of the significance of those results. Several of these companies included proposals for integrity programs that they considered appropriate for their pipelines. Additional information requests to enhance the clarity or completeness of phase one evidence were addressed by the Board to Amoco, TMPL, and IPL.

Under phase two, in accordance with Section 3.2 of the OHW-1-89 Directions on Procedure, the Board requested information from operators of liquids-carrying pipelines under the Board's jurisdiction that did not submit evidence under phase one. Three such operators were: Murphy Oil Company Ltd. ("Murphy"); Montreal Pipe Line Ltd. ("MPL"); and Sun Pipe Line Co., who although registered as interested parties to the review, did not file phase one sampling results. These companies were requested to indicate whether their facilities incorporated welds within the scope of Recommendation 5.9, to describe any testing programs carried out thereon, and to describe the effect Recommendation 5.9 would have on them. Responses were received from Murphy and MPL. The Board also addressed letters to the eight operators of liquids carrying pipelines under its jurisdiction not registered as interested parties to the review. These letters summarily described the review proceedings to that date, requested information about any welds within the scope of Recommendation 5.9 on each company's system, and indicated to each addressee how to register as an interested party. One response was received, from Esso Resources Canada Ltd. ("Esso").

Tables I and II on pages 4 and 5 summarize the phase one sampling evidence received by the Board and the further information received under Section 3.2 of the OHW-1-89 Directions on Procedure. Generic issues raised during the review are dealt with in Chapters 1 through 9 of these Reasons for Decision. The Board's decision is detailed in Chapter 10 which is composed of Section 10.1 respecting Recommendation 5.9 itself and of Section 10.2 respecting disposition of company-specific submissions.

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1. On 1 May 1989, Dome Petroleum Limited and Hudson's Bay Oil and Gas Company Limited amalgamated to form Amoco Canada Resources Ltd.

Table I

IPL Sampling Results Summary[1]

Line designation	Old Line 1 Edm-Regina	Line 2	Line 3	Line13 Former Line 1 Regina-Greta	Line 4	Line 5	Line 6	Line 7	Line 8	Line 9	Line 10	Line 11
Representative line pipe CE[2]	(0.49)	0.42	0.43	(0.49)	(0.43)	Over 0.40		Over 0.40	Over 0.40	0.38		
No. sleeve welds	28	674	188	24	4	20	0	24	36	684	0	0
No. welds inspected	28	202	60	24	4	10	0	4	10	118		
Welds with toe cracks	5	19	0	2	0	1	0	0		1		
Welds with root cracks	0	19	0	0	0	0	0	0	0			
Both on same weld	0	0	0	0	0	0	0	0	0			
Overall cracking rate	18%	19%	0%	8%	0%	10%		0%	0%	0.8%		
No fitting welds stopples&other)	176	438	446	126	0	18	6	26	0	42	10	4
No. welds inspected	176	148	138	34	0	6	2	10		4	10	4
Welds with toe cracks	57	12	12	0	0	1	0	0		0	0	
Welds with root cracks	9	3	2	0	0	0	0	0		0	0	
Both on same weld	1	0	0	0	0	0	0	0		0		
Overall rate of cracking	38%	10%	10%	0%		16%	0%	0%		0%		
No branch connection welds	*	*	*	*	*	*	*	*	*	*	*	*
No welds inspected	9	23	25	6	0	0	0	0	0	0	0	0
Welds with toe Cracks	1	0	0	0								
Welds with root cracks	0	0	0	0								
Both on same weld	0	0	0	0								
Overall rate of cracking	11%	0%	0%	0%								

* Unknown

1 as submitted by IPL on 28 September and revised on 12 October 1989

2 entries in parentheses from IPL Inquiry Report

Table II

Sampling Results Summary

Company Representative line pipe CE	TMPL 0.36	TMPL 0.48	PTC 0.28	Dome	Murphy	MPL 0.40 (457mm Line) 0.44 (610 mm line)	Esso
No sleeve welds	1406	108	272	20	0	38	0
No welds inspected	308	34	16	20		0	
Welds with toe cracks	0	7[1]	0	0			
Welds with root cracks	0	3[1]	3	0			
Both on same weld	0		0	0	0		
Overall rate of cracking	0		18%	0			
No fitting welds (stopples & other)	452	22	152	24	2	0	0
No welds inspected	22	10	48	24	0		
Welds with toe cracks	0	1[1]	0	0			
Welds with root cracks	0	3[1]	9	0			
Both on same weld	0	1[1]	0	0			
Overall rate of cracking	0		18%	0			
No branch connection welds				*			
No welds inspected				4			
Welds with toe cracks				0			
Welds with root cracks				0			
Both on same weld				0			
Overall rate of cracking				0%			

* Unknown

1 These results refer to the number of sleeves or fittings with at least one of the two full encirclement fillet welds cracked.

Chapter 2

Scope of Recommendation 5.9

Recommendation 5.9, as it appears in the Inquiry Report, applies to any existing welds made to liquid-filled pipe. The CPA argued that there was no indication that welds other than sleeve-to-pipe fillet welds are a problem. The Committee and PTC stated that inspection of welds should be restricted to those susceptible to cracking, *i.e.*, full encirclement fillet welds made to liquid-filled pipe. The Committee proposed to exclude branch connection welds since, in its view, that configuration had not been the subject of the MH-2-85 Inquiry and stresses acting on branch-to-pipe welds are not normally sufficient to cause cracking.

Following completion of its sampling program, wherein 63 branch connections were inspected, IPL submitted that such welds need not be the subject of further inspections within the scope of Recommendation 5.9. It argued that only one of the branch connections sampled was found to be cracked and that no such weld had ever contributed to a significant line failure. However, IPL stated that the industry agrees that branch connection welds could be susceptible to cracking, and further stated that the industry would be prepared to continue inspecting branch connection welds found or completed at any time that lines were uncovered.

In its letter to the Committee Chairman of 22 July 1988, the Board indicated that it was not persuaded that branch connections should be beyond the scope of the recommendation. The Board indicated that before deciding if the proposed change in scope is appropriate, it would require the submission of nondestructive testing ("NDT") results taken from branch connections on those pipelines for which the sampling results had demonstrated recurrent fillet weld cracking.

Tables I and II summarize the results of NDT submitted pursuant to the sampling programs. IPL was the only operator that inspected a significant number of branch connection welds. Neither TMPL nor PTC, both of which found recurrent incidents of encirclement fillet weld cracking, submitted data regarding branch connection welds. Overall, 67 branch-to-carrier pipe welds were inspected, resulting in the detection of one crack.

Views of the Board

The Inquiry Panel's Recommendation 5.9 applied to existing welds made to liquid-filled pipe, *i.e.*, welds existing at the time of release of the Inquiry Report on 23 July 1986. The scope of the requirements resulting from these Reasons for Decision should be consistent in this respect with that of the Inquiry Panel's recommendation. The Board believes that the likelihood of continuing to encounter weld cracking has been substantially reduced by the implementation of the other recommendations respecting welding procedures, NDT procedures and improved line maintenance techniques, coupled with industry's greater awareness of the potential problems associated with maintenance welding.

Regarding branch connections, the data submitted for the review are not as extensive as the Board had desired for consideration of a change to this aspect of the recommendation. The industry-wide applicability of the data filed may be debatable given that it was provided predominantly by only one operator. Nonetheless, insofar as the data are valid, the Board agrees with IPL's interpretation thereof, *i.e.*, that branch connection welds could be susceptible to cracking but that a major problem of recurrent branch connection weld cracking is not indicated.

As a result, the Board does not consider it to be justified to exclude branch connection welds from the scope of the recommendation. However, the Board supports IPL's proposal that existing buried branch connection welds be nondestructively examined whenever uncovered. This, in conjunction with appropriate remedial measures, would

result in a gradual decrease over time of the number of potentially cracked branch connection welds and would make further data available for a better understanding of the scope of the problem. As the inspections would be done on the occasion of excavations made necessary in any event for other operational reasons, the benefits would be achieved without the added risk associated with excavating operating pipelines and at modest incremental cost .

Some pipelines may incorporate a number of above-ground branch connection welds within the scope of the recommendation. The Board believes that, because such welds are most often easily accessible for inspection, the integrity of each above-ground branch connection weld should be nondestructively verified as soon as practicable.

For two reasons, branch connection welds that are covered by reinforcing saddles or full encirclement tees should not be within the scope of Recommendation 5.9. Firstly, since the reinforcing member prevents any access to the branch connection weld itself, no NDT of the branch-to-carrier pipe weld can be performed. Secondly, as demonstrated by Appendix A to the Committee's submission on Recommendation 5.8, the presence of the reinforcement significantly reduces the level of bending stresses transmitted to the vicinity of the branch-to-carrier pipe weld, making the propagation of any existing crack much less likely.

Chapter 3

The Pipe Age Criterion for Gauging Susceptibility

The Inquiry Panel's Recommendation 5.9 required more extensive remedial measures for welds made to pipe manufactured during or prior to 1970 than for welds made to more recently manufactured pipe. In the early 1970s, many pipe mills began to use steel that tended to have a lower carbon equivalent ("CE"). The division between pre- 1 January 1971 and post-1970 pipe vintages would enable a broad distinction to be made between pipe highly susceptible to cracking and pipe that is less susceptible and would take into account pipelines for which documentation regarding pipe composition is unavailable.

The Committee expressed its disagreement with the use of the date of pipe manufacture as an indicator of susceptibility to hydrogen-induced weld cracking. This view was widely held among participants in the review. The Committee argued that it would be more appropriate to relate the probability of cracking to the chemical composition of the steel as defined by its CE. The Committee suggested that the formula in the CSA standard CAN3-Z183-M86 be used to calculate the CE. In the absence of data on the trace elements, an alternate formula developed by IPL could be used.

The Committee further suggested that a CE of 0.40 percent should be considered as the dividing point above which pipe would be treated as being more likely to exhibit cracking of fillet welds made while the pipe was liquid-filled. The Committee's sampling program provided for an increased rate of sampling for pipe where average CE exceeded 0.40 percent (30 percent vs 15 percent of the pipe welds). In cases where pipe material information was lacking, the higher CE level was to be assumed.

In its submission of 2 November 1989, IPL argued that it was reasonable, on the basis of the sampling results, to exclude remaining in-service welds from further inspections if the CE of the line were less than 0.40 percent. IPL supported this proposal by comparing the results among its own and TMPL's high CE lines where, according to IPL, similar rates of injurious fillet weld toe cracks were reported, with TNPL's low CE pipeline where no incidence of cracking was detected.

Views of the Board

The Board agrees with the Committee that it is the chemical composition of the steel as represented by the CE and not the year of pipe manufacture *per se* that is the relevant criterion for gauging susceptibility to cracking. For purposes of the phase one sampling programs, the Board agreed with the Committee's proposal to use a CE level of 0.40 percent to assign line pipe into high- and low-risk groups. In the absence of CE data, the high CE level was to be assumed but in any event both the higher and lower CE groups were to receive a sufficient degree of sampling to determine whether a problem existed.

The Board is of the view that, although the CE can define a higher or lower susceptibility to cracking, the CE alone cannot adequately predict whether or not cracking is in fact present on a particular pipeline. The occurrence of a crack is the result of the combined effect of the amount of hydrogen present during welding, the level of tensile stress, as well as the material's microstructural susceptibility to cracking. Microstructural susceptibility is itself a function of the steel's CE and the rate of cooling experienced after welding. The particulars as to welding procedures, related work practices and conditions present at the time of welding could vary significantly affecting the likelihood of cracking independent of changes in pipe CE. In addition, the pipe CE at the location being welded could be substantially different from the nominal or average value.

The sampling results filed illustrate the inappropriateness of using CE to predict the presence of cracking. For example all instances of toe cracks

occurred on pipe with a CE greater that 0.40 percent but not all pipelines with such a CE were affected by cracking. On pipelines with a CE below 0.40 percent, no instances of toe cracks were reported but PTC reported a significant rate of root cracks although the sleeve materials were apparently also below a CE of 0.40 percent.

The Board is of the view that the present decision should not base the need for remedial measures on any direct or indirect assessment of susceptibility to cracking. Rather, such measures should be triggered by the actual condition of the welds in a particular pipeline, that is, whether or not the line is affected by recurrent cracking as determined by a program of representative sampling similar to that developed by the Committee. The Board will therefore require companies that have pipeline welds within the scope of this decision and that have not yet carried out the Committee's sampling program, to carry out sampling regardless of the pipe's vintage or CE. The Board will require the sample to be representative and the Committee's minimum sampling rate of 15 percent and minimum sample size to be respected. Sampling data obtained in this way will permit the Board to confidently distinguish pipelines affected from those not affected by recurrent weld cracking. The Board will require each affected company to submit for approval, first a detailed sampling plan, followed by the sampling results and analysis. Eighteen months will be allowed for carrying out sampling so as to permit the excavations and backfilling to be performed under warm weather conditions, thereby facilitating the restoration of adequate bearing support for the pipelines.

Chapter 4

Interpretation of Sampling Results

4.1 Recurrent Cracking

The objective of the sampling program described in the previous chapter is to determine whether any pipeline system or portion thereof is affected by recurrent cracking of welds within the scope of this decision.

Views of the Board

The Board will consider recurrent weld cracking to be any significant frequency of weld or heat affected zone cracking found by NDT, regardless of reported dimensions, other than isolated occurrences that are demonstrably attributed to factors not present generally on the pipeline.

4.2 Grouping

The Committee suggested that, for purposes of a sampling program, fillet welds on a pipeline should be grouped not only in respect of the CE as already discussed in Chapter 3, but also in respect of the type of component involved, such as sleeves, stopple fittings or couplings. The Committee contended that this is appropriate because of the different restraints and stresses imposed on the pipe. Furthermore, the Committee argued that the measures triggered by crack detection should apply only to the respective component/CE group.

IPL proposed another form of grouping when arguing that the identification of crack-prone sections of line "relate crack incidence to relevant factors such as pipeline history, geography and operation". To take account of pipeline length, IPL argued that "long pipelines should be allowed to report sections rather than the total system". "A longer pipeline", it argued, "would allow greater opportunities for a defect than would a shorter pipeline". Under IPL's proposal, the remedial measures triggered by defect detection would apply to 50 km of line on either side of the defect. This, IPL stated, would influence the extent of the required action.

Views of the Board

In its letter of 22 July 1988 to the Committee Chairman, the Board indicated that it must review a company's rationale for grouping in conjunction with the results of the sampling program before deciding what further action is required.

Having reviewed the sampling results submitted under phase one, the Board is of the view that the results support, in specific cases, the individual consideration of certain groups of components in respect of their status, being either affected or not affected by cracking. In all such cases, the grouping would represent a range of validity of the sampling results, having regard to the causes of weld cracking. For instance, as argued by the Committee, a distinction between sleeves and fittings would reflect the significantly different stresses and restraints that these could impose on the carrier pipe. Similarly, grouping pipelines constructed of different materials or maintained using different procedures would be legitimate, as would be a distinction between toe and root cracks that involve the line pipe and sleeve or fitting material, respectively. However, a valid judgment about a grouping can only be drawn if the sample size inspected for that group is in accordance with a minimum size required for statistical validity. The Committee suggested that a minimum of 30 welds be inspected. If the total population were to number less than 30, the Committee suggested that all must be inspected. The Board concurs with this minimum sample size.

The Board finds that the validity of sampling data is not purely a function of distance from a detected defect. In addition, the Board does not believe that longer pipelines are, as a result of their length, more likely to suffer from recurrent cracking. Hydrogen-induced weld cracking is not a random occurrence, but results from the action of physical factors which make the affected/not affected distinction appropriate.

The Board's views on grouping are reflected in the disposition of the company-specific sampling results and integrity proposals found in Chapter 10, and will be reflected in the Board's disposition of future sampling results submitted in compliance with this decision.

Chapter 5

Root Cracks and Toe Cracks

Four general types of sleeve or fitting to pipe fillet weld cracks have been recognized and are illustrated in Figure 1 below. The type 1 crack is referred to as a "toe" crack. A toe crack such as this was determined by the Inquiry Panel to have propagated circumferentially through the pipe wall causing the line break near Camrose. The type 2, 3 and 4 cracks are referred to as "root" cracks. The potential occurrence of fillet weld root cracks came to light during the conduct of the weld inspections for this review. Where the nature of the root cracks detected was identified, they were indicated to be predominantly of type 2 with isolated occurrences of type 3. Although type 4 cracks are identified as a potential type of fillet weld crack, no report of such cracks has in fact resulted from the inspection programs.

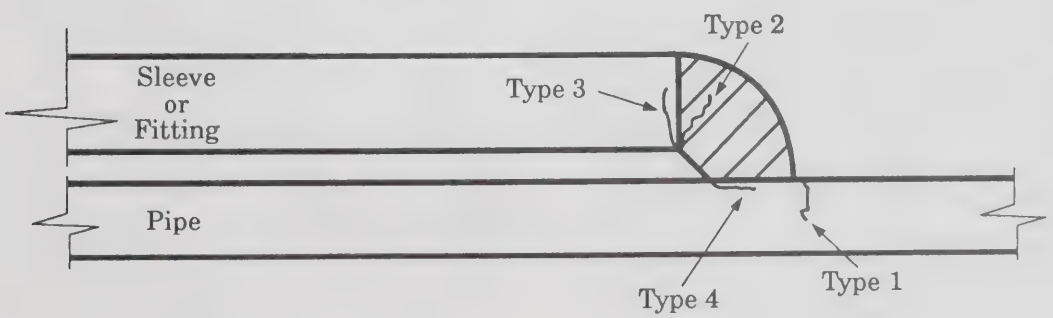
PTC submitted that according to an analysis it had commissioned, it was considered that, in the unlikely event of a root crack leading to failure, the worst case consequences would be a renewal of leakage where the sleeve or fitting was pressurized. In any event, root cracks were considered unlikely to propagate unless extremely large and subject to extraordinary loads. Fracture of the line pipe would not occur. Since most sleeves on the PTC system were installed to contain pinhole leaks, PTC judged these to be of no significant public risk. However, the company stated that a root crack failure on a stopple fitting could result in a release of large volumes of product and, as a result, proposed to examine all stopples and replace any that incorporate cracked fillet welds.

IPL argued that the detection of root cracks is unreliable and often leads to unnecessary repairs with their own attendant risk. IPL contended that, in view of its own and PTC's findings, "the presence of root cracks should not influence the remaining inspection programs."

TMPL indicated that it would have a study conducted to determine the relationship between root cracks and pipeline integrity. However, no results were reported to the Board.

Figure 1

Potential Fillet Weld Crack Types



Type 1- Toe crack

Types 2, 3, and 4 - Root cracks

Views of the Board

The analyses submitted by PTC attempted, in part, to quantify the behavior of fillet weld root cracks at sleeves and stopple fittings. As discussed in Chapter 7, the Board considers that the validity of such analyses in respect of fillet weld cracks has not been established and that the quantitative conclusions drawn in those analyses are not reliable.

However, the significance of root cracks can be considered in terms of the consequences of such a crack propagating to failure. Since root cracks do not compromise the integrity of the carrier pipe wall, the Board accepts PTC's position that, in any event, a crack would not cause fracture of the carrier pipe. Re-opening of a leak path from beneath the sleeve or fitting would be potentially serious in cases where the sleeve had been used to repair a significant leak, or in the case of couplings or stopple fittings that retain the line contents. Where a sleeve had been applied to reinforce non-leaking defects or over minor "pinhole" leaks, the Board agrees that the consequences of root crack propagation would be insignificant.

The NDT procedures (Appendix III) attached to the Committee's position paper on Recommendation 5.7, were designed to detect root cracks as well as toe cracks. PTC submitted the results of twelve destructive tests to verify the performance of the NDT in respect of root cracks. The NDT rejected four welds where no cracking was later found. In four cases the NDT diagnosis of cracks was confirmed as was the NDT finding of no cracks in the remaining four cases. While recognizing the risk, cost and inconvenience of unnecessary repairs due to false positive NDT indications, the Board finds that these difficulties do not justify inaction where NDT indicates cracking. The Board views the performance of the NDT inspection for root cracks positively in that the cracking that was present was detected. Unnecessary repairs resulting from false positive NDT indications would be minimized if repairs were required only in cases where root crack propagation could lead to significant leakage.

Chapter 6

Nondestructive Testing Reliability

The Committee recommended that any requirement for removal of fillet welds be based on the results of NDT. The Committee contended that its position paper on Recommendation 5.7 had shown that reliable NDT procedures had been developed. This position was echoed in the submissions from PTC and IPL. In addition, IPL indicated that the inspection procedures and the related procedures for proficiency testing of technicians are being drafted into recommended practices for issue by the CPA.

The capability and reliability of the Committee's NDT procedures for fillet weld crack detection (Appendix III) were considered by the Board in its deliberations on Recommendation 5.7. In its letter to the Committee Chairman of 22 July 1988, the Board indicated that it considered the NDT reliability to be sufficient to provide a qualitative measure of the condition of a pipeline system, *i.e.*, to be used to carry out the sampling program proposed for phase one of the review of Recommendation 5.9. However, where the welding procedure used is known to produce or suspected of producing welds that are susceptible to cracking, the Board stated that it had concerns in respect of the crack detection reliability of the proposed NDT procedures. Where the results of the sampling program for a particular system of portion thereof demonstrated recurrent fillet weld cracking, the Board indicated that it would take into consideration its concerns about the crack detection reliability of the NDT procedures in deliberating on the disposition of the fillet welds involved.

When carrying out the phase one sampling program, the Board required that the performance of the NDT procedure be closely monitored. The Board expected data collected through this monitoring to provide a more accurate measure of the procedures' crack detection reliability. In fact, only PTC filed new information related to the performance of NDT. This information respecting the detection of root cracks is described in Chapter 5.

Views of the Board

In the case of pipelines found on the basis of sampling to be affected by recurrent fillet weld cracking, the Board has decided to accept the use of the Committee's NDT procedures for determination of the integrity of individual welds in all low vapour pressure ("LVP") and in Zone 1 areas of high vapour pressure ("HVP") pipelines. This decision is based on the following factors:

1. submissions regarding the performance of NDT filed by the Committee which suggest that the reliability of NDT in detecting fillet weld cracks is between 74 percent and 82 percent;

2. larger cracks, which are more critical to pipeline integrity than smaller ones, would be those most reliably detected;

3. the qualification testing of inspection technicians to demonstrate proficiency in the NDT procedure, beyond the minimum qualification requirements of the Canadian General Standards Board; and

4. the level of public risk posed by potential leakage from LVP pipelines and from HVP pipelines in Zone 1 areas.

The Board has decided not to accept the use of NDT for determination of the integrity of individual fillet welds in Zone 2 areas of HVP pipelines found to be affected by recurrent fillet weld cracking. The Board will require such welds to be cut out of the pipeline or contained within a sleeve-on-sleeve assembly. This decision is based upon the following factors:

1. submissions from the Committee indicating the inability of the NDT techniques to detect upwards of 18 per cent of existing fillet weld cracks; and

2. the relatively high public risk posed in the event of leakage from HVP pipelines in Zone 2 areas.

Chapter 7

Engineering Critical Assessment

The Committee submitted that engineering critical assessment ("ECA") of fillet weld cracks should be employed in the context of the sampling program and as part of integrity assurance. Within the sampling programs, the Committee had suggested that, for pipelines in other than HVP service, the rate of sampling would be increased to 100 percent of the sample group if a crack deemed to be injurious by ECA was found. ECA would not be employed for HVP pipelines.

For the purpose of integrity programs, the Committee's position was that ECA should be permitted to determine whether or not a crack is injurious. An example of such an assessment was appended to the Committee's submission. As previously stated, use of ECA would be allowed only in non-HVP pipelines.

Amoco, TNPL, PTC and IPL generally supported the position that the disposition of welds found to contain cracks should consider, via an ECA, whether or not the defect is injurious to the safe operation of the pipeline.

PTC as part of its submission for the review provided a detailed ECA of certain fillet weld root cracks found on its system. The quantitative aspects of this analysis were based on the following assumptions:

(i) that cyclic pressure variations would be small and as a result, fillet weld failure would be due only to constant loading; and

(ii) that the fillet weld could be considered to be similar to a pipeline girth weld and therefore use of British Standards Institute document PD6493[1] would be conservative.

Views of the Board

The issue of whether cracked fillet welds can be assessed as to their fitness for continued service using the principles of fracture mechanics was dealt with in the Board's letters of 22 July 1988 to the Committee Chairman regarding Recommendations 5.11 and 5.7, and the phase one sampling proposal for the review of Recommendation 5.9. The Board indicated that it considered the use of ECA on fillet weld cracks to be inappropriate since no proven methodology for analyzing defects in fillet welds had been established and because of unresolved difficulties regarding the required input data. The study conducted for the Board by Battelle Memorial Institute entitled "Impact on Pipeline Integrity Due to Crack Acceptance" dated 23 December 1987, discusses these matters in detail. The Board is not aware of any significant subsequent technical developments nor has the present review persuaded the Board that its position in respect of ECA should be modified. Since the critical crack size cannot be satisfactorily defined, all fillet weld cracks detected must continue to be considered significant.

The detailed analyses of fillet weld root cracks submitted by PTC contain valuable qualitative information regarding the behavior of such cracks. As discussed in Chapter 5, the Board has made allowance for the less significant consequences of a root crack failure. However, the assumptions underlying the quantitative analyses are in fact among the matters determined to require additional verification before being considered applicable to fillet welds. The Board considers that it cannot rely on the quantitative conclusions drawn in the PTC analyses.

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1. British Standards Institute document PD 6493: 1980 entitled "Guidance on some methods for the derivation of acceptance levels for defects in fusion welded joints".

Chapter 8

Remedial Measures for Cracked Fillet Welds

Recommendation 5.9 as it appeared in the Inquiry report required that all welds containing cracks be removed by cutting out and replacing the cylindrical piece of pipe containing the defect.

The Committee argued that it should be permissible to repair or "remove from service" fillet welds found to contain unacceptable cracks.

Amoco and TNPL submitted that not all welds that contain cracks should necessarily be cut out. TMPL suggested that cut-outs or double sleeving be applied only for weld toe cracks of such depth (greater than 0.5 mm) that they could not be repaired by grinding and re-welding.

PTC argued that toe cracks should be removed from service while root cracks may or may not require removal depending on whether they were judged to be injurious.

IPL submitted in its letter of 2 November 1989 that whenever possible, fillet welds found to contain cracks should be treated by cut-out and pipe replacement. However, IPL stated that "removing the cracked section from service by containing it within a sleeve-on-sleeve repair or grinding to remove the crack while leaving a pipe wall thickness of not less than 92%, have been proven to be successful." Finally, IPL considered that procedures involving grinding and rewelding and ECA "can be finalized in the near future" as a result of "ongoing activity around the world".

Views of the Board

The Board agrees that certain repair techniques in addition to cutting out and replacing a cylindrical piece of pipe containing the defect are acceptable as remedial measures for cracked fillet welds. The techniques that could be used to treat fillet weld cracks were addressed in the Board's decision dated 22 July 1988 on Recommendation 5.11, as amended on 16 February 1989. The effect of this decision was to allow the repair of fillet weld cracks by the following additional methods:

(i) repair of the crack by grinding out the affected area, followed by rewelding if necessary; and

(ii) enclosure of the cracked weld within a pressure-tight sleeve-on-sleeve assembly.

The decision on Recommendation 5.11, as amended, details the various constraints applicable to the use of these techniques.

The Board finds that, where remedial measures for cracked fillet welds are required by this decision, the acceptable methods shall be those permitted under Recommendation 5.11, as amended.

Chapter 9

Pipeline-specific Implementation of Integrity Programs

The Inquiry Panel's Recommendation 5.9 contained requirements applicable to all companies under Board jurisdiction.

The CPA indicated that companies should be given an opportunity to demonstrate through a suitable program of testing that their welding techniques have not induced cracks. Such welds should then be treated as sound and not require removal. This view was shared by Amoco.

The submission from the Committee suggested criteria for an inspection program of welds within the scope of the Recommendation 5.9. The Committee Chairman stated in his covering letter that when carried out, the program would identify the particular pipelines where it may be necessary to remove fillet welds, and those where such welds may be safely left in service. Board orders for corrective action could then be issued to specific companies while the remainder would not have to be burdened.

Several pipeline operators (TMPL, TNPL and PTC) submitted that the measures required to enhance pipeline integrity should be tailored to the needs of each pipeline rather than be a single industry-wide standard. The factors that were said to merit consideration in this regard were the physical properties of the materials involved, location, product carried and operating conditions.

In the course of the review, the Board accepted the Committee's proposal to conduct the review of Recommendation 5.9 in two phases so as to permit companies to examine their pipelines and gather further evidence demonstrating whether or not their particular welds are affected by the cracking problem. The Board commented on certain aspects of the inspection program designed by the Committee for this evidence gathering, which was subsequently carried out by five pipeline operators. In addition, the Board solicited information from those operators that did not file sampling results.

Views of the Board

The Board agrees that, based on the results of an adequate representative sampling program, a sufficiently clear differentiation can be made between pipelines affected by recurrent cracking of fillet welds and those not affected. The Board agrees that, for those pipelines or portions thereof judged on the basis of sampling to be not affected by cracking, no additional integrity measures should be required. The Board is of the view that this approach will assure the integrity of affected pipelines within its jurisdiction while subjecting those not affected by the problem to minimum burden. For the pipeline operators that have already carried out satisfactory sampling and submitted results, the Board has made the affected/not affected determinations found in Chapter 10 Section 10.2.

Not all pipeline companies potentially affected by Recommendation 5.9 participated in the review, and not every participant with welds within the scope of the recommendation submitted sampling results. This decision requires companies with welds within this decision's scope to carry out sampling if they have not already done so.

Companies judged on the basis of sampling to be affected by recurrent cracking will be required to implement further integrity measures. The Board recognizes the advantages of tailoring the integrity measures to the needs of each pipeline. However, the Board is also of the view that a consistent minimum level of safety must be assured across its jurisdiction. To meet these objectives, the Board is issuing in Chapter 10 Section 10.1, new requirements constituting the minimum level of integrity assurance applicable to all companies. Each company-specific submission already received is individually treated in Chapter 10 Section 10.2, using such minimum requirements as the acceptance criteria. Future submissions will be given similar consideration.

Chapter 10

Decision

10.1 Decision Regarding Recommendation 5.9

Recommendation 5.9 of the Camrose Accident Inquiry Panel's MH-2-85 report is rescinded and the following substituted therefor:

"1. Scope

This decision is applicable to welds performed before 23 July 1986 to liquid-filled pipe. This decision does not apply to branch connection welds located under reinforcing fittings including full encirclement tees.

2. Sampling Program for Full Encirclement Fillet Welds

Companies operating pipelines with full encirclement fillet welds within the scope of this decision shall conduct a sampling program to ascertain whether the pipelines are affected by recurrent cracking of these welds. The program shall consist of excavating and nondestructively examining for cracking a sample of at least 15 percent of such welds, the minimum number of welds in the sample to be 30 except where the total number of such welds is less than 30, in which case all such welds shall be inspected. The sample shall be selected so as to be representative of the welds along the full length of each pipeline being investigated. The NDT inspection shall comprise both ultrasonic and magnetic particle testing in accordance with procedures equivalent to those submitted to the Board by the Committee (Appendix III), and shall be carried out by technicians qualified and proficiency tested in accordance with the Board's decision on Recommendation 5.7. All companies operating liquids-carrying pipelines, except those that have already filed the results of a satisfactory sampling program, shall file for Board approval prior to conducting sampling and no later than 31 January 1991, a document indicating the number of subject welds on their respective pipelines, and indicating their proposed program and schedule for conducting the sampling.

3. Sampling Results

No later than 18 months following approval of a company's sampling program by the Board, the company shall have completed the program and shall file for Board approval the results, its analysis of the significance of the results and its program and schedule for meeting the requirements applicable if recurrent weld cracking exists.

4. Recurrent Cracking

The Board considers recurrent weld cracking to be any significant frequency of weld or heat affected zone cracking found by NDT, regardless of dimensions, other than isolated occurrences that are demonstrably attributed to factors not present generally on the pipeline.

5. Integrity Program for Pipelines Affected by Recurrent Cracking of Full Encirclement Fillet Welds

(a) High Vapour Pressure Pipelines Located in Zone 2 Areas

All full encirclement fillet welds in Zone 2 areas of HVP pipelines or portions thereof determined to be affected by the recurrent cracking of these welds, except those welds used to attach sleeves over non-leaking or minor pinhole leak defects in such pipelines affected by root cracking only, shall be either:

(i) removed by cutting out of the cylindrical piece of pipe containing the weld and replacing it with pre-tested pipe meeting design requirements; or

(ii) contained within a sleeve-on-sleeve assembly installed in accordance with the Board's decision on Recommendation 5.11, as amended.

(b) High Vapour Pressure Pipelines Located in Zone 1 Areas and all Low Vapour Pressure Pipelines

All full encirclement fillet welds in pipelines or portions thereof determined to be affected by recurrent cracking of these welds, other than those defined in paragraph 5(a) above and those welds used to attach sleeves over non-leaking or minor pinhole leak defects in pipelines affected by root cracking only, shall be excavated and nondestructively examined for cracking. The NDT shall be as described in paragraph 2 above.

6. Integrity Program - Above-Ground Branch Connection Welds

Companies operating pipelines with above-ground branch connection welds within the scope of this decision shall nondestructively examine each such weld for cracking as soon as practicable. The NDT shall be as described in paragraph 2 above. Companies shall file for approval no later than 31 January 1991, their program and schedule for complying with this requirement and shall compile and retain records of these examinations for submission to the Board on request.

7. Integrity Program - Buried Branch Connection Welds

When buried branch connection welds within the scope of this decision are uncovered for any reason, companies shall nondestructively examine each such weld for cracking. The NDT shall be as described in paragraph 2 above. Companies shall compile and retain records of these examinations for submission to the Board on request.

8. Acceptability of Cracks Detected by NDT

Toe cracks detected by NDT performed under paragraphs 2, 5(b), 6, and 7, shall be unacceptable, regardless of their reported dimensions. It shall be permissible for companies to accept for continued service root cracks in fillet welds used to install sleeves over non-leaking line pipe defects or over minor pinhole leaks. Root cracks in fillet welds used to install pressure retaining fittings such as stopples or couplings, or sleeves over more significant leaks shall be unacceptable regardless of their reported dimensions.

9. Dealing with Unacceptable Cracks

Companies shall remedy unacceptable cracks through methods in accordance with the Board's decision on Recommendation 5.11, as amended."

10.2 Decision Regarding Disposition of Company-specific Submissions

1. TNPL

TNPL indicated that it has carried out extensive nondestructive as well as destructive testing of sleeves and fittings on its pipeline, and has found no incidence of fillet weld cracking. The company submitted that its system is not affected by sleeve fillet weld cracking and that further investigation or implementation of Recommendation 5.9 would be inappropriate for it. Nonetheless, the company stated that it is in its third year (1989) of an ongoing program of removing sleeves installed prior to 1986 in all built-up urban areas, within 1,000 feet of significant water crossings, and within the right-of-way limits of all road and rail crossings. As further development occurs, sleeves within the newly affected areas will be removed.

The Board finds that TNPL has conducted a satisfactory sampling program in accordance with the requirements of this decision. The Board finds that the results demonstrate TNPL's pipeline is not affected by full encirclement fillet weld cracking and requires no further action in regard to these welds. However, the Board notes and supports the company's decision to remove sleeves installed in specific high-risk areas.

The company shall examine branch connection welds on its pipeline in accordance with paragraphs 6 and 7 of Section 10.1 and shall file for approval no later than 31 January 1991 its schedule for complying with paragraph 6.

2. Amoco

Amoco indicated that it had not identified any instances of cracking at either the toe or root areas of the fillet welds in its pipeline systems. It main-

tained that only those welds where NDT detected cracking should require remedial measures.

The Board finds that Amoco has conducted a satisfactory sampling program in accordance with the requirements of this decision. The Board accepts the company's conclusion that the sampling did not identify any instances of cracking and therefore finds that the Amoco pipelines[1] are not affected by full encirclement fillet weld cracking.

Amoco shall examine branch connection welds on its pipelines in accordance with paragraphs 6 and 7 of Section 10.1 and shall file for approval no later than 31 January 1991 its schedule for complying with paragraph 6.

3. PTC

PTC indicated that its sampling program found fillet weld root cracks but no toe cracks. These findings were confirmed by the destructive testing of 12 welds. According to the company, analysis of random samples has shown that its pipeline has a low CE of 0.28 percent. PTC submitted that these factors indicated virtually no risk of toe cracking on its pipeline.

Regarding the root cracks, PTC indicated that such cracks were unlikely to fail, and even if such failure occurred, the worst scenario would entail the reopening of a leak path which would itself be restricted by the tightness of the fillet weld cracks. PTC stated that the sleeves on its line were generally installed over minor pinhole leaks and were not considered to be a significant risk to the public or to its employees. PTC believed it to be unnecessary to undertake any additional inspections of sleeve fillet welds. However, according to the company, root cracks associated with stopples should be removed from service due to the potential for release of large volumes of product in the event of failure.

The company proposed an integrity program that included:

(i) carrying out an aerial infrared leak survey;

(ii) nondestructively examining all remaining stopple fittings; and

(iii) removing all defective stopples on a prioritized basis beginning in 1989.

The Board finds that PTC has submitted the results of a satisfactory sampling program in accordance with the requirements of this decision. The Board finds that PTC's pipeline is not affected by encirclement fillet weld toe cracking, but that it is affected by recurrent root cracking of those welds. The Board finds PTC's proposed integrity program to be appropriate and requires the company to file for approval no later than 31 January 1991 the schedule for its completion.

PTC shall examine branch connection welds on its pipeline in accordance with paragraphs 6 and 7 of Section 10.1 and shall file for approval no later than 31 Janiary 1991 its schedule for complying with paragraph 6.

4. TMPL

The company's sampling program indicated a significant occurrence of both root and toe cracks on sleeves and fittings. In response, the company undertook the following measures:

(i) extending of the nondestructive testing program to cover 100 percent of sleeve and stopple fillet welds, to have been completed by the end of 1989;

(ii) attempting to repair by filing or grinding superficial fillet weld toe cracks less than 12.7 mm in length and 0.5 mm in depth. Each crack would be evaluated for the appropriateness of replacement or repair. Any defect requiring replacement would be treated by cut-out and replacement of the cylindrical piece of pipe; and

(iii) deferring remedial measures for sleeves and stopples with root cracks, pending the results of destructive testing by a consultant to evaluate the "significance of the anomalies to pipeline integrity". (No results of the tests have been reported to the Board.)

The Board finds that TMPL has submitted the results of a satisfactory sampling program in accordance with the requirements of this decision. The Board finds that the company's pipeline is affected by recurrent toe and root cracking of full

1. The Cochin Pipeline System, the Empress-Kerrobert Pipeline System, The Eastern Delivery System, and the Sarnia Downstream System.

encirclement fillet welds. The Board further finds that the integrity measures undertaken by the company comply with paragraphs 5 (b), 8 and 9 of Section 10.1 in the respect of toe cracks. The Board requires TMPL to submit for approval no later than 31 January 1991 an update on the status of its integrity program, and its program and schedule for coming into full compliance (*i.e.*, root cracks as well as toe cracks) with paragraphs 5(b), 8 and 9 of Section 10.1.

TMPL shall examine branch connection welds on its pipeline in accordance with paragraphs 6 and 7 of Section 10.1 and shall file for approval no later than 31 January 1991 its schedule for complying with paragraph 6.

5. IPL

In a letter dated 30 November 1989, the company submitted the following integrity program which it felt would complete the measures flowing from Recommendation 5.9:

(i) no further action for Lines 5,6,7,8 and 9;

(ii) lines 2 and 3 to be divided into four sections each corresponding to pipeline maintenance crew territories. The objective of the program is to nondestructively inspect at least 30 percent of the sleeves and fittings on Line 2 and 30 percent of the fittings on Line 3; and

(iii) detection of an "injurious defect (as judged by industry rules)" would trigger further 100 percent inspections of sleeves or fittings of a similar type within the vicinity, either 50 km on either side of the fitting or the entire section as described under (ii) above.

Based on the sampling results filed, the Board finds as follows:

> Lines 1, 2, and 5 - Affected by recurrent fitting- and sleeve-to-pipe fillet weld cracking;
>
> Line 3 - Affected by recurrent fitting-to-pipe fillet weld cracking. Not affected by sleeve-to-pipe fillet weld cracking;
>
> Line 1 - Affected by recurrent sleeve-to-pipe fillet weld cracking. Not affected by fitting-to-pipe fillet weld cracking;
>
> Lines 4, 9, 10 and 11 - Not affected by full encirclement fillet weld cracking; and
>
> Lines 6, 7 and 8 - The sample size is below the minimum stipulated in Section 10.1 paragraph 2 and is therefore inconclusive.

In respect of Lines 1 and 13, the company indicated that all the affected welds have already been inspected. In addition, the Board noted that Line 1 between Regina and Gretna has been recently replaced as were portions near populated areas or with clusters of sleeves on Line 1 between Edmonton and Regina.

Regarding IPL's proposed integrity program, the Board finds that certain aspects of the program must be modified to be acceptable. In particular, these are as follows:

(iv) having found Line 5 to be affected by recurrent full encirclement fillet weld cracking, the Board requires that treatment of this line be added to the company's integrity program;

(v) the Board requires that the company's integrity program for pipelines or portions thereof judged affected by recurrent cracking of encirclement fillet welds be in accordance with paragraphs 5(a) or 5(b) as applicable, of Section 10.1; and

(vi) the Board requires that all unacceptable cracks, as defined in paragraph 8 of Section 10.1 be remedied through a method in accordance with paragraph 9 of Section 10.1.

No later than 31 January 1991, IPL shall file for approval, its program and schedule for coming into full compliance with this decision. This program shall include:

(vii) provision for such additional sampling as required to meet the minimum sample size for Lines 6, 7, and 8;

(viii) a revised integrity program that complies with the requirements of items (iv), (v), and (vi) above; and

(ix) a program and schedule for examining branch connection welds in accordance with paragraph 6 of Section 10.1.

Disposition

The foregoing chapters constitute our Reasons for Decision and our Decision on this matter.

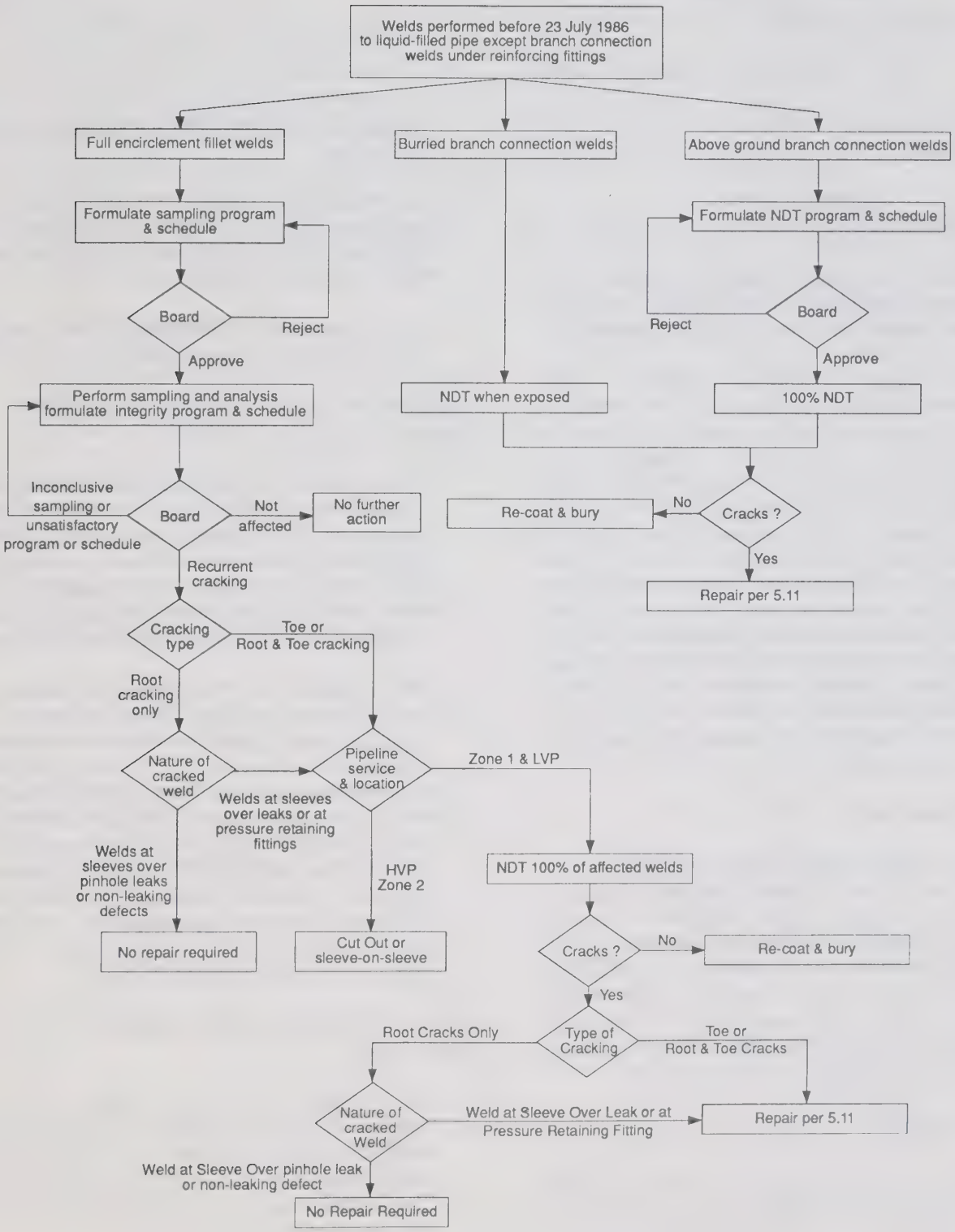
D.B. Smith
Presiding Member

R. Priddle
Member

R.B. Horner Q.C.
Member

Ottawa, Ontario September 1990

Schematic Representation of Recommendation 5.9, as Amended



File No. : 1764-J1-2
1 June 1989

ORDER OHW-1-89
DIRECTIONS ON PROCEDURE

Review of Recommendation 5.9: Integrity of Existing Pipelines in the National Energy Board's MH-2-85 Report Dated June 1986

By application dated 6 October 1986, Interprovincial Pipe Line Limited (now Interhome Energy Inc. carrying on its pipeline activities as Interprovincial Pipe Line Company) (the "Applicant") applied to the National Energy Board (the "Board") for a review of the Recommendation 5.9 in the Board's MH-2-85 Report. On 23 October 1986, the Board granted the Applicant's request for a review, and subsequently agreed on 21 July 1988 that the review be conducted in two phases. Phase one consisted of the gathering and submission to the Board of additional evidence. In respect of phase two, that of the review itself, the Board directs that the format of the review shall be by written submission in accordance with the following procedure:

Public Viewing

1. The Applicant shall deposit and keep on file, for public inspection during normal business hours, a copy of the application and all submissions from phase one and subsequently from phase two in its offices at 10201 Jasper Avenue, Edmonton, Alberta. A copy of these documents is also available for viewing in the Board's Library, Room 962, 473 Albert Street, Ottawa, Ontario.

Interventions

2.1 Parties who have filed submissions in phase one and those who appear in the list of Interested Parties appended hereto, shall be considered Interested Parties to phase two of the review.

2.2 Any Party who is not at this time listed as an Interested Party by who wishes to participate in phase two, shall file an intervention with the Secretary by 7 July 1989.

2.3 The Secretary will amend the list of Interested Parties shortly after 7 July 1989.

Completeness and Clarity of Phase One Evidence

3.1 On or before 15 June 1989, the Board will request clarifications or corrections to deficiencies in the evidence that was filed with the Board in phase one. Affected parties will have until 7 July 1989 to file responses with the Secretary and serve one copy on the Applicant and each of the Interested Parties.

3.2 On or before 15 June 1989, the Board will seek information from the operators of liquids-carrying pipelines under the Board's jurisdiction who did not submit evidence during phase one. The Board will be inquiring as to whether their facilities incorporate welds within the scope of Recommendation 5.9 and if so, as to their number and nature. Affected parties will have until 7 July 1989 to file their information response with the Secretary and serve one copy on the Applicant and each of the Interested Parties.

Submissions of Interested Parties - Phase Two

4. On or before 1 September 1989, Interested Parties shall file their phase two submissions with the Secretary and serve one copy on the Applicant and each of the Interested Parties. The Board requests Interested Parties who file submissions to, inter alia:

(a) clearly set out their position regarding Recommendation 5.9;
(b) comment on the new evidence filed in phase one and in respect of paragraph 4 above;

(c) indicate what aspects, if any, of Recommendation 5.9 they find to be impractical, unreasonable, difficult or too expensive to apply, and provide the supporting reasons therefor; and

(d) indicate any proposed alternatives to achieving the objectives of Recommendation 5.9 with an explanation of how these alternatives may be applied, and provide supporting documentation.

Comments by Interested Parties

5. On or before 6 October 1989, Interested Parties are required to file any comments on the phase two submissions with the Secretary and serve one copy on the Applicant and each of the Interested Parties.

General

6. Parties are requested to quote File Number 1764-J1-2 and Order OHW-1-89 when corresponding with the Board in this matter.

7. These Directions on Procedure supplement the Draft NEB Rules of Practice and Procedure dated 21 April 1987.

8. For information on this proceeding or the procedure governing the proceeding, contact Mrs. Joyce McGuire, Regulatory Support Officer at (613) 998-7205.

Louise Meagher
Secretary

File No. : 1764-J1-2
Date: 31 August 1989

Order No. AO-1-OHW-1-89
(Amending and Supplementing Hearing Order OHW-1-89)
Amendment to Directions on Procedure

BEFORE the Board on 29 August 1989.

Review of Recommendation 5.9: Integrity of Existing Pipelines in the National Energy Board's HM-2-85 Report Dated June 1986.

By letter dated 16 August 1989, Interprovincial Pipe Line Company (the "Applicant ") indicated that certain relevant field work will not be completed until 1 September 1989 and requested an extension of the filing deadline for phase two submissions. The National Energy Board (the "Board"), having reviewed the request from the Applicant, considers it to be in the public interest to grant the extension requested.

It is ordered that Order OHW-1-89 be amended by deleting paragraph 4. and 5. and substituting the following therefor:

Submission of Interested Parties - Phase Two

4. On or before 30 September 1989, Interested Parties shall file their phase two submissions with the Secretary and serve one copy on the Applicant and each of the Interested Parties. The Board requests Interested Parties who file submissions to, *inter alia*:

(a) include any further relevant evidence;

(b) clearly set out their position regarding Recommendation 5.9;

(c) comment on the new evidence filed in phase one and in respect of paragraph 3 above;

(d) indicate what aspects, if any, of Recommendation 5.9 they find to be impractical, unreasonable, difficult or to expensive to apply, and provide the supporting reasons therefor; and

(e) indicate any proposed alternatives to achieving the objectives of

Recommendation 5.9 with an explanation of how these alternatives may be applied, and provide supporting documentation.

Comments by Interested Parties

5. On or before 3 November 1989, Interested Parties are required to file any comments on the phase two submissions with the Secretary and serve one copy on the Applicant and each of the Interested Parties.

NATIONAL ENERGY BOARD

Louise Meagher
Secretary

MAGNETIC PARTICLE PROCEDURE WIC/MT

Electromagnetic Yoke Method for Testing Lap Welds on Reinforcing Sleeves Attached to Pipelines

1.0 Scope

1.1 This is a general procedure defining the guidelines to be followed for the magnetic particle testing of lap welds on reinforcing sleeves attached to pipelines. The objective of the test is to detect cracks propagating into the pipe wall in the area of the weld toe and open to the test surface. The test will also detect cracks under the weld bead orientated parallel to the pipe outside surface, and open to the test surface at the weld toe. The test will also detect lack of fusion between the weld and the pipe wall and open to the test surface.

2.0 Standards and Specifications

2.1 The equipment required in this procedure is based on: ASME Boiler and Pressure Vessel Code Section V, Article 7.

3.0 Qualification of Personnel

3.1 Personnel performing this inspection shall be qualified in accordance with the requirements of C.G.S.B. Standard 48-GP-8M.

3.2 Only C.G.S.B. Level II or Level III shall establish procedures or techniques.

3.3 Weldment scanning will be carried out by Level II or III technicians.

3.4 Only Level II or Level III Technicians shall interpret results.

4.0 Material

4.1 This procedure shall be used when inspecting carbon steel lap welds of the configuration detailed in Figure 1.

5.0 Equipment

5.1 AC/DC electromagnetic yoke: Parker or equivalent

5.2 Wet visible penetrant Ardrox 803 (or equivalent).

5.3 Ardrox 386 W (or equivalent) white background laquer.

6.0 Calibration

6.1 a) The magnetizing force of yokes shall be calibrated by determining their lifting power.

b) Each alternating current electromagnetic yoke shall have a lift. power of at least 10 lb (4.5 kg) at the maximum pole spacing that will be used.

c) Each direct current yoke shall have a lifting power of at least 40 lb (18.1 kg) at the maximum pole spacing that will be used.

7.0 Surface Preparation

7.1 Surfaces to be magnetic particle tested shall be dry and free from oil, rust, loose scale paint or other material which might interfere with the formation or interpretation of magnetic particle patterns or indications.

8.0 Magnetizing Procedure

8.1 The white laquer background shall be applied to the area to be tested.

8.2 Magnetization shall be accomplished by passing the current through the part in accordance with Fig. 2.

8.3 The magnetizing current shall not be turned off until the proper contact has been made and the indicating medium applied.

Note. Except for materials 1/4" (6 mm) or less in thickn alternating current yokes are superior to direct current yokes .. equal lifting power for the detection of surface discontinuities.

9.0 Acceptance Standards

9.1 All relevant linear indications in the area of the weld toe shall be cause for rejection.

9.2 Where the cause of the indications is determined to be weld undercut, the undercut will be blended smoothly into parent material and the area shall be retested.

10.0 Reporting

10.1 All relevant linear indications shall be recorded and mapped using a format similar to Figure 2.

10.2 Customers name and address

10.3 Indentification of the weld and location

10.4 Magnetizing current (AC or DC)

10.5 Name of inspector and qualifications

10.6 Operators signature

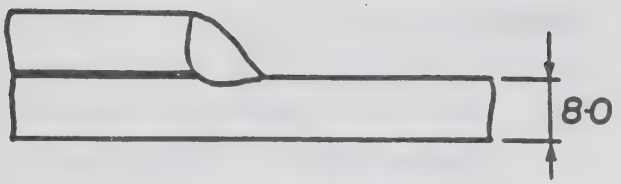
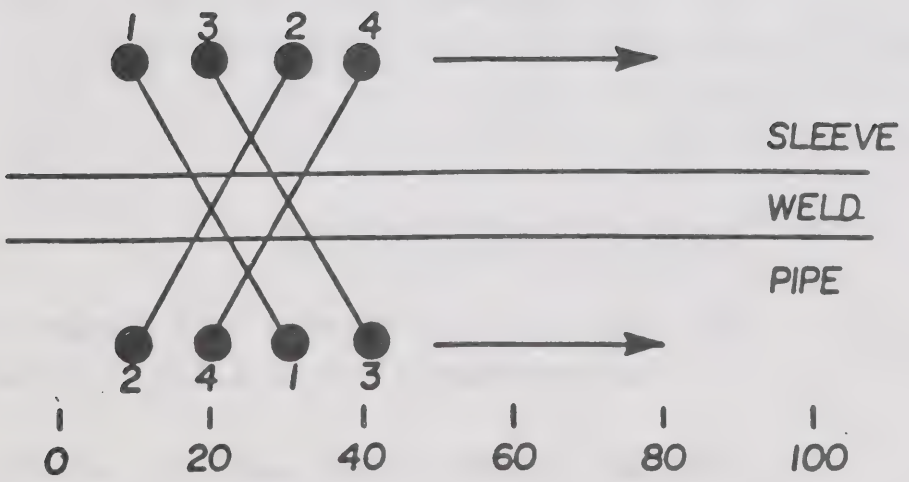


Figure 1. Layout Scheme.



Note: Placement of the yoke shall be as indicated above. Overlapping of positions shall be such that the magnetic field will cover the weld 100%.

Figure 2. Display Schematic.

ULTRASONIC INSPECTION OF FILLET WELDS ON REINFORCING SLEEVES ATTACHED TO PIPE LINES

1.0 Scope:

1.1 This is a general procedure for the ultrasonic inspection of fillet welds on reinforcing sleeves attached to pipe lines. The aim of this inspection is to detect cracks in the root and toe areas of the weld.

2.0 Standards and Specifications:

2.1 The equipment shall conform to the requirements of A.S.M.E. Section 5, Article 5.

3.0 Personnel Qualifications:

3.1 Personnel performing this inspection shall be qualified in accordance with C.G.S.B. Standard 48-GP-7M.

3.2 Only Level II or Level III technicians shall carry out inspection.

4.0 Equipment:

4.1 Sonic MK1 or equivalent pulse-echo type instrument.

4.2 Frequency one (1) to five (5) MHz.

4.3 Probes:

- 0° 2.25 MHz 1/4" dia. Dual Crystal
- 70° 2.25 MHz 1/4" dia. Single Crystal
- 60° 2.25 MHz 1/4" dia. Single Crystal

4.4 Calibration Blocks:

- DSC Block
- Fabricated Sensitivity Test Block (Figure 1)

4.5 Couplant:

- 10W30 Oil
- Lubriplate 105 Grease
- Cellufiber and Water

NOTE Probe selection may be adjusted according to thickness of the carrier pipe and sleeve. On thinner wall materials, it may be possible to use only the 70° transducer.

5.0 Calibration:

5.1 Time Base Calibration

Longitudinal wave 0° Transducer
The time base shall be calibrated to display a minimum of two (2) back reflections for thickness to be scanned.

5.2 Angle Beam Calibration

Shear Wave Transducers
The time base shall be calibrated to display 100mm screen using DSC Block.

Angle beam exit point and angles of refraction shall be checked.

5.3 A lamination scan shall be carried out prior to weld inspection. Laminations are not cause for rejection, but shall be noted on reports.

5.4 Calibration for Sensitivity

Shear Wave Transducers
The response on the CRT from the 0.01" notch in the calibration sample, shall be adjusted to 50% of full screen height. Refer to Figure 1. This will be known as the reference level record machine settings.

5.5 At the same gain setting, scan for the 0.020" and 0.050" notches. Record responses as percentage of full screen height.

5.6 A correction value shall be applied to the sensitivity level arrived at in Paragraph 5.3 to compensate for differences in sound attenuation between the calibration sample and the component under test, as detailed in A.S.M.E. Section V.

5.7 Scanning sensitivity shall be +6db above or more than reference level as determined by the inspector. This shall be recorded.

5.8 When inspecting the root of the fillet weld, scan for 1/16" drilled holes in the calibration sample and set response to 80% screen height. Record gain setting.

6.0 Surface Preparation:

6.1 Surfaces from which inspections are to be carried out shall be free from weld splatter, loose paint, scale or other abnormalities that might interfere with inspection.

7.0 Scanning:

7.1 Probe movement shall be in parallel paths with at least a 10% overlap to ensure complete coverage.

7.2 Weld inspection shall be carried out as outlined in the techniques for the individual transducer. Refer to Figures 2 and 3.

7.3 Figure 2, Scan 1 70° Angle Beam Scan - Scan 1
For detection of cracks from the toe to the root of the weld.

7.4 Figure 2, Scan 2 70° Angle Beam Scan - Scan 2
For detection of cracks from the root of the weld.

SPECIAL NOTE 70° angle beam scan cannot be carried out on Scan 2 on Plidco sleeves as the "O"-ring slot blocks the sound path from this angle.

7.5 Figure 4, 60°, 70° Angle Beam Scan
For defects in vertical leg of welded sleeves. Should defects arise in the upward leg of weld, loss of signal will result from the weld cap, or an introduction of a new signal at closer range on time base.

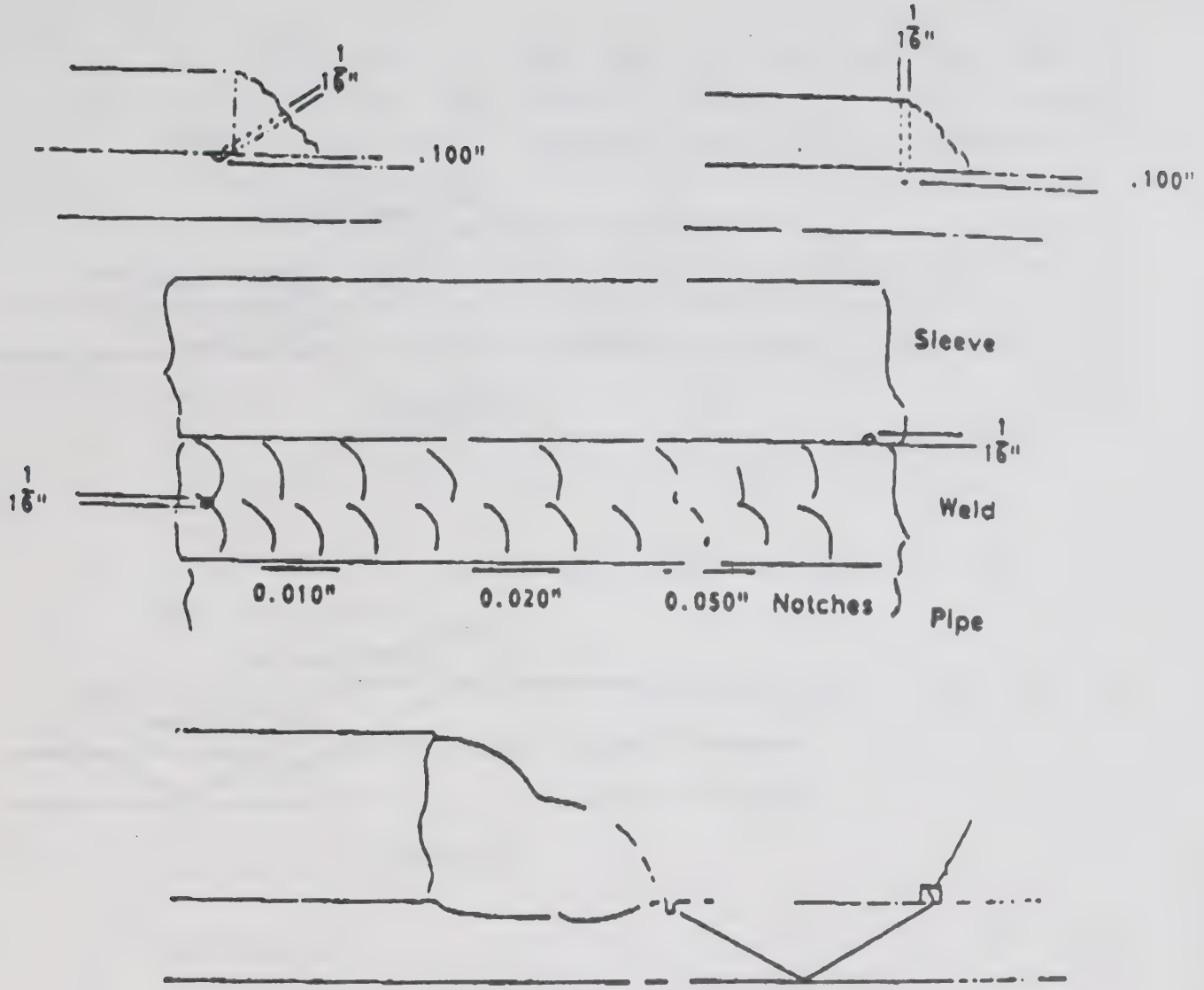


FIGURE 1

Calibration Standard

a) Notches vertical to the pipe wall and .500 in. long, .0625 wide

b) Notches shall have parallel sides and flat bottom

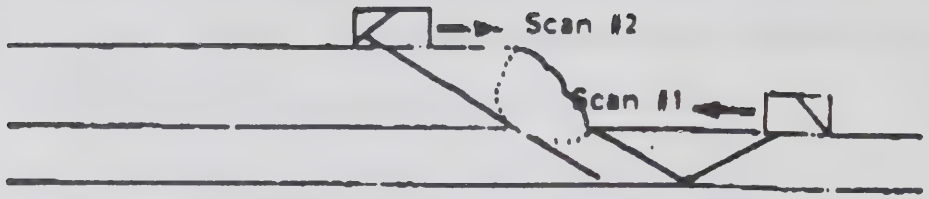


FIGURE 2

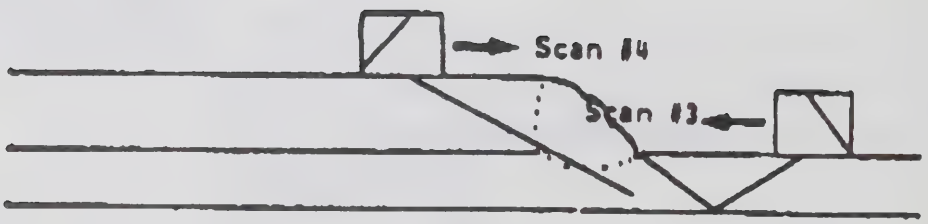


FIGURE 3

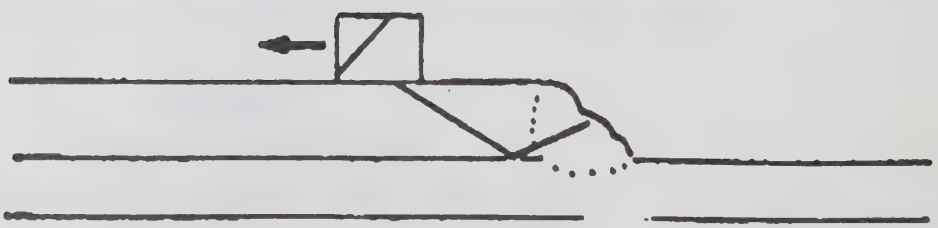


FIGURE 4

8.0 Recording:

8.1 All indications in the area of interest over 10% of reference level and having a length of 3 mm or greater shall be evaluated. Undercutting shall be blended out and area retested.

8.2 Sensitivity test block #2 will give indications from toe cracking approximately 0.015" in depth and root cracking approximately 2 mm in height. This test piece should be employed as a comparison of signals from welded sleeves to give better evaluation of defect indications, and location of these defects on the time base of the CRT.

8.3 Lengths of all indications shall be measured using the 6db drop method.

8.4 Indications determined to be cracks shall be recorded on a plan view of the weld, Figure 5.

9.0 Acceptance Standard:

9.1 Acceptability of welds shall be based on the applicable requirements of CSA Standards Z183 and Z184.

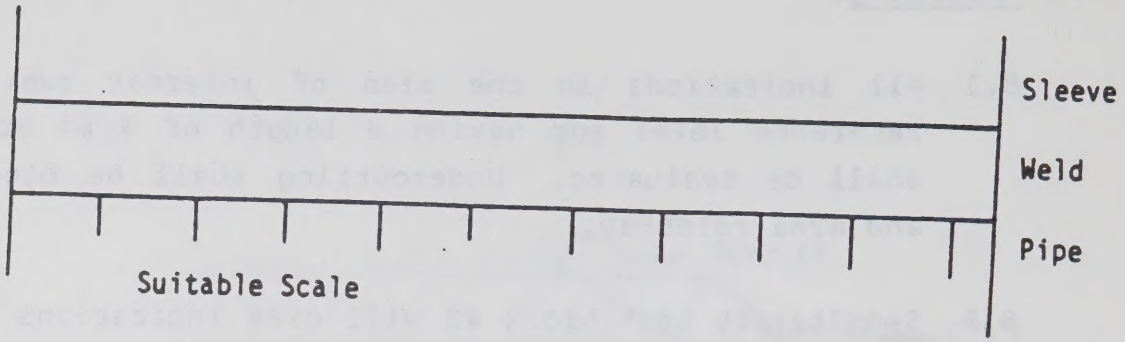


Figure 5. Display Schematic